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REISSUE PATENT APPLICATION TRANSMITTAL

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Assistant Commissioner for Patents
Box Patent Application
Washington, DC 20231

Attorney Docket No.	MTS-880US1
First Named Inventor	Thiow Keng Tan
Original Patent Number	5,825,421
Original Patent Issue Date (Month/Day/Year)	October 20, 1998
Express Mail Label No.	EL711312241US

APPLICATION FOR REISSUE OF: (check applicable box) [X] Utility Patent [ ] Design Patent [ ] Plant Patent

APPLICATION ELEMENTS

1. [X] * Fee Transmittal Form *(PTO/SB/56)* *(Submit an original, and a duplicate for fee processing)*
2. [X] Specification and Claims *(amended, if appropriate)*
3. [X] Drawing(s) *(proposed amendments, if appropriate)*
4. [X] Reissue Oath / Declaration (original or copy) *(37 C.F.R. § 1.175)(PTO/SB/51 or 52)*
5. Original U.S. Patent
   - [X] Offer to Surrender Original Patent *(37 C.F.R. § 1.178)(PTO/SB/53 or PTO/SB/54)*
   - *or*
   - [ ] Ribboned Original Patent Grant
   - [ ] Affidavit / Declaration of Loss *(PTO/SB/55)*
6. Original U.S. Patent currently assigned?
   - [X] Yes [ ] No

   (If Yes, check applicable box(es))
   - [ ] Written Consent of all Assignees *(PTO/SB/53 or 54)*
   - [X] 37 C.F.R. § 3.73(b) Statement [X] Power of Attorney

ACCOMPANYING APPLICATION PARTS

7. [X] Foreign Priority Claim *(35 U.S.C. 119)* *(if applicable)*
8. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
9. [ ] English Translation of Reissue Oath/Declaration *(if applicable)*
10. [ ] * *Small Entity* Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard *(MPEP 503)* *(Should be specifically itemized)*
13. [ ] Other: .....

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REISSUE APPLICATION FEE TRANSMITTAL FORM

Docket Number (Optional)
MTS-880US1

Claims as Filed - Part 1

Claims in Patent	For	Number Filed in Reissue Application	(3) Number Extra	Small Entity Rate	Small Entity Fee		Other than a Small Entity Rate	Other than a Small Entity Fee
(A)	Total Claims (37 CFR 1.16(j))	(B)	**** =	x $___ =		or	x $___ =	
(C)	Independent Claims (37 CFR 1.16(i))	(D)	* =	x $___ =		or	x $___ =	
			Basic Fee (37 CFR 1.16(h))		$___			$___
			Total Filing Fee		$		OR	$ 710

Claims as Amended - Part 2

	(1) Claims Remaining After Amendment		(2) Highest Number Previously Paid For	(3) Extra Claims Present	Small Entity Rate	Small Entity Fee		Other than a Small Entity Rate	Other than a Small Entity Fee
Total Claims (37 CFR 1.16(j))	*** 16	MINUS	** 20	* = 0	x $___ =		or	x $ 18 =	0
Independent Claims (37 CFR 1.16(i))	*** 7	MINUS	***** 6	= 1	x $___ =		or	x $ 80 =	80
				Total Additional Fee		$		OR	$ 80

* If the entry in (D) is less than the entry in (C), Write "0" in column 3.
** If the "Highest Number of Total Claims Previously Paid For" is less than 20, Write "20" in this space.
*** After any cancelation of claims
**** If "A" is greater than 20, use (B -A); if "A" is 20 or less, use (B - 20).
***** "Highest Number of Independent Claims Previously Paid For" or Number of Independent Claims in Patent (C).

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Allan Ratner, Reg. No. 19,717
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CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10)

Applicant(s): **Thiow Keng Tan**

Docket No. **MTS-880US1**

Serial No.	Filing Date	Examiner	Group Art Unit
To Be Assigned	**Herewith**		

Invention: **VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF**

I hereby certify that the following correspondence:

Reissue Application and its enclosures

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VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention can be used in low bit rate video coding for tele-communicative applications. It improves the temporal frame rate of the decoder output as well as the overall picture quality.

2. Related art of the Invention

In a typical hybrid transform coding algorithm such as the ITU-T Recommendation H.261 [1] and MPEG [2] motion compensation is used to reduce the amount of temporal redundancy in the sequence. In the H.261 coding scheme, the frames are coded using only forward prediction, hereafter referred to as P-frames. In the MPEG coding scheme, some frames are coded using bi-direction prediction, hereafter referred to as B-frames. B-frames improve the efficiency of the coding scheme. Now the [1] is ITU-T Recommendation H.261 (Formerly CCITT Recommendation H.261) Codes for audiovisual services at p×64 kbit/s Geneva, 1990 , and the [2] is ISO/IEC 11172-2 1993 , Information technology—Coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s - Part 2: Video.

However, it introduces delay in the encoding and decoding, making it unsuitable for applications in the communicative services where delay is an important parameter. FIG. 1*a* and 1*b* illustrates the frame prediction of H.261 and MPEG as described above. A new method of coding involving the coding of the P and B frames as a single unit, hereafter referred to as the PB-frame, was introduced. In this scheme the blocks in the PB-frames are coded and transmitted together thus reducing the total delay. In fact the total delay should not be more than a scheme using forward prediction only but at half the frame rate.

FIG. 2*a* shows the PB-frame prediction. A PB-frame consists of two pictures being coded as one unit. The name PB comes from the name of picture types in MPEG where there are P-frames and B-frames. Thus a PB-frame consists of one P-frame which is predicted from the last decoded P-frame and one B-frame which is predicted both from the last decoded P-frame and the P-frame currently being decoded. This last picture is called B-frame because parts of it may be bi-directionally predicted from the past and future P-frame.

FIG. 2*b* shows the forward and bi-directional prediction for a block in the B-frame, hereafter referred to as a B-block. Only the region that overlaps with the corresponding block in the current P-frame, hereafter referred to as the P-block, is bi-directionally predicted The rest of the B-block is forward predicted from the previous frame. Thus only the previous frame is required in the frame store. The information from the P-frame is obtained from the P-block currently being decoded.

In the PB-block only the motion vectors for the P-block is transmitted to the decoder. The forward and backward motion vectors for the B-block is derived from the P motion vectors. A linear motion model is used and the temporal reference of the B and P frame is used to scale the motion vector appropriately. FIG. 3*a* depicts the motion vector scaling and the formula is shown below.

$$MV_F = TR_B \times MV / TR_P \quad (1)$$

$$MV_B = (TR_B - TR_P) \times MV / TR_P \quad (2)$$

where

MV is the motion vector of the P-block.

MV_F and MV_B are the forward and backward motion vectors for the B-block.

TR_B is the increment in the temporal reference from the last P-frame to the current B-frame, and

TR_P is the increment in the temporal reference from the last P-frame to the current P-frame.

Currently the method used in the prior art assumes a linear motion model. However this assumption is not valid in a normal scene where the motion is typically not linear. This is especially true when the camera shakes and when objects are not moving at constant velocities.

A second problem involves the quantization and transmission of the residual of the prediction error in the B-block Currently the coefficients from the P-block and the B-block are interleaved in some scanning order which requires the B-block efficients to be transmitted even when they are all zero. This is not very efficient as it is quite often that there are no residual coefficients to transmit (all coefficients are zero).

SUMMARY OF THE INVENTION

In order to solve the first problem, the current invention employs a delta motion vector to compensate for the non-linear motion. Thus it becomes necessary for the encoder to perform an additional motion search to obtain the optimum delta motion vector that when added to the derived motion vectors would result in the best match in the prediction This delta motion vectors are transmitted to the decoder at the block level only when necessary. A flag is used to indicate to the decoder if there are delta motion vectors present for the B-block.

For the second problem, this invention also uses a flag to indicate if there are coefficients for the B-block to be decoded.

The operation of the Invention is described as follows.

FIG. 3*a* shows the linear motion model used for the derivation of the forward and backward motion vectors from the P-block motion vector and the temporal reference information As illustrated in FIG. 3*b*, this model breaks down when the motion is not linear. The derived forward and backward motion vector is different from the actual motion vector when the motion is not linear. This is especially true when objects in the scene are moving at changing velocities.

In the current invention the problem is solved by adding a small delta motion vector to the derived motion vector to compensate for the difference between the derived and true motion vector. Therefore the equations in (1) and (2) are now replaced by equations (3) and (4), respectively.

$$MV_F' = TR_B \times MV / TR_P - MV_{Delta} \quad (3)$$

$$MV_B' = (TR_B - TR_P) \times MV / TR_P - MV_{Delta} \quad (4)$$

where

MV is the motion vector of the P-block.

MV_{Delta} is the delta motion vector.

MV_F' and MV_B' are the new forward and backward motion vectors for the B-block according to the current invention.

TR_B is the increment in the temporal reference from the last P-frame to the current B-frame, and

TR_P is the increment in the temporal reference from the last P-frame to the current P-frame.

Note: Equations (3) and (4) are used for the motion vector in the horizontal as well as the vertical directions. Thus the motion vectors are in pairs and there are actually two independent delta motion vectors, one each for the horizontal and vertical directions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1*a* is a prior art which illustrates the prediction mode used in the ITU-T Recommendation H.261 Standard.

FIG. 1*b* is a prior art which illustrates the prediction mode used in the ISO-IEC/JTC MPEG Standard.

FIG. 2*a* illustrates the PB-frame prediction mode.

FIG. 2*b* illustrates the B-block bi-directional prediction mode.

FIG. 3*a* illustrates the linear motion model.

FIG. 3*b* illustrates the non-linear motion model of the current invention

FIG. 4 illustrates the encoder functionality block diagram.

FIG. 5 illustrates the B-block bi-directional prediction functionality block diagram.

FIG. 6 illustrates the decoder functionaltity block diagram.

PREFERRED EMBODIMENTS

The preferred embodiment of the current invention is described here. FIG. 4 illustrates the encoding functionality diagram. The present invention deals with the method for deriving the motion vectors for the B-block. The encoding functionality is presented here for completeness of the embodiment.

The encoding functionality block diagram depicts an encoder using a motion estimation and compensation for reducing the temporal redundancy in the sequence to be coded. The input sequences is organized into a first frame and pairs of subsequent frames. The first frame, hereafter referred to as the I-frame, is coded independent of all other frames. The pairs of subsequent frames, hereafter referred to as PB-frame, consist of a B-frame followed by a P-frame. The P-frame is forward predicted based on the previously reconstructed I-frame or P-frame and the B-frame is bi-directionally predicted based on the previously reconstructed I-frame or P-frame and the information in the current P-frame.

The input frame image sequence, 1, is placed in the Frame Memory 2. If the frame is classified as an I-frame or a P-frame it is passed through line 14 to the Reference Memory 3, for use as the reference frame in the motion estimation of the next PB-frame to be predictively encoded. The signal is then passed through line 13 to the Block Sampling module 4, where it is partitioned into spatially non-overlapping blocks of pixel data for further processing.

If the frame is classified as an I-frame, the sampled blocks are passed through line 16 to the DCT module 7. If the frame is classified as a PB-frame, the sampled blocks are passed through line 17 to the Motion Estimation module 5. The Motion Estimation module 5 uses information from the Reference Frame Memory 3 and the current block 17 to obtain the motion vector for that provides the best match for the P-block The motion vector and the local reconstructed frame, 12, are passed through line 19 and 20, respectively, to the Motion Compensation module 6. The difference image is formed by subtracting the motion compensated decoded frame, 21, from the current P-block, 15. This signal is then passed through line 22 to the DCT module 7.

In the DCT module 7, each block is transformed into the DCT domain coefficients. The transform coefficients are passed through line 23 to Quantization module 8, where they are quantized. The quantized coefficents are then passed through line 24 to the Run-length & Variable Length Coding module 9. Here the coefficients are entropy coded to form the Output Bit Stream 25.

If the current block is an I-block or a P-block, the quantized coefficients are also passed through line 26 to the Inverse Quantization module 10. The output of the Inverse Quantization 10, is then passed through line 27 to the Inverse DCT module 11. If the current block is an I-block then the reconstructed block is placed, via line 28, in the Local Decoded Frame Memory 12. If the current block is a P-block then the output of the Inverse DCT 29 is added to the motion compensated output 21, to from the reconstructed block 30. The reconstructed block 30, is then placed in the Local Decoded Frame Memory 12, for the motion compensation of the subsequent frames.

After the P-block have been locally reconstructed, the information is passed again to the Motion Compensation Module 6, where the prediction of the B-block is formed. FIG. 5 shows a more detailed functional diagram for the B-block prediction process. The P-motion vector derived in the Motion Estimation module 51, is passed through line 57 to the Motion Vector Scaling Module 53. Here the forward and backward motion vectors of the B-block is derived using the formula (1) and (2), respectively. In the present embodiment, an additional motion search around these vectors is performed in the Delta Motion Search module 54, to obtain the delta motion vector. In this embodiment the motion vector is obtained by performing the search for all delta motion vector values between −3 and 3. The delta motion vector value that gives the best prediction in terms of the smallest mean absolute difference in the pixel values of the B-block and the prediction block is chosen. The prediction is formed in the Bi-directional Motion Compensation module 55, according to FIG. 2*b* using the information from the Local Decoded Frame Memory 52, and the Current Reconstructed P-block 50. In the bi-directional prediction, only information available in the corresponding P-block is used to predict the B-block. The average of the P-block information and the information from the Local Decoded Frame is used to predict the B-block. The rest of the B-block is predicted using information from the Local Decoded Frame only.

The prediction difference block is then passed through line 22 to the DCT module 7. The DCT coefficients are then passed through line 23 to the Quantization module 8. The result of the Quantization module 8, is passed through line 24 to the Run-length & Variable Length Coding 9. In this module the presence of the delta motion vector and the quantized residual error in the Output Bitstream 25, is indicated a variable length code, NOB which is the acronym for No B-block This flag is generated in Run-length & Variable Length Coding module 9 based on whether there are residual error in the Quantization module 8 and delta motion vectors found in the Delta Motion Search module 54 is not zero. Table 1 provides the preferred embodiment of the variable length code for the NOB flag. The variable length code of the NOB flag is inserted in the Output Bitstream, 25, prior to the delta motion vector and quantized residual error codes.

TABLE 1

(Variable length code for the NOB flag)

NOB	Quantized Residual Error Coded	Delta Motion Vectors Coded
0	No	No
10	No	Yes
110	Yes	No
111	Yes	Yes

FIG. 6 shows the functional block diagram for the decoder. The Input Bit Stream 31. is passed to the Variable Length & Run Length Decoding module 32. The block and side information are extracted in this module. If the frame is a PB-frame then the bitstream is checked if any delta motion vector and/or quantized residual error coefficients present. The output of the module 32 is passed through line 37 to the Inverse Quantisation module 33. The output of the Inverse Quantization 33. is then passed through line 38 to the Inverse DCT module 34. Here the coefficients are transformed back into the pixel values.

If the current frame is an I-frame then the output of Inverse DCT 34. is passed through line 39 and stored in the Frame Memory 42.

If the current frame is a PB-frame. the side information containing the motion vectors are passed through line 45 to the Motion compensation module 36. The motion Compensation module 36. uses this information and the information in the Local Decoded Memory. 35. to from the motion compensated signal. 44. This signal is then added to the output of the Inverse DCT module 34. to form the reconstruction of the P-block.

The Motion Compensation module 36. then uses the additional information obtained in the reconstructed P-block to obtain the bi-directional prediction for the B-block. The B-block is then reconstructed and placed in the Frame Memory. 42. together with the P-block.

By implementing this invention. the temporal frame rate of the decoded sequences can be effectively doubled at a fraction of the expected cost in bit rate. The delay is similar to that of the same sequence decoded at half the frame rate.

As described above in the present invention a new predictive coding is used to increase the temporal frame rate and coding efficiency without introducing excessive delay. Currently the motion vector for the blocks in the bi-directionally predicted frame is derived from the motion vector of the corresponding block in the forward predicted frame using a linear motion model. This however is not effective when the motion in the image sequence is not linear. According to this invention. the efficiency of this method can be further improved if a non-linear motion model is used. In this model a delta motion vector is added to or subtracted from the derived forward and backward motion vector. respectively. The encoder performs an additional search to determine if there is a need for the delta motion vector. The presence of this delta motion vector in the transmitted bitstream is signalled to the decoder which then takes the appropriate action to make use of the delta motion vector to derive the effective forward and backward motion vectors for the bi-directionally predicted block.

What is claimed:

1. A method for encoding a sequence of video image frames comprising the steps of:

dividing a source sequence into a set of group of pictures. each group of pictures comprising a first frame

(I-frame) followed by a plurality of pairs of predictively encoded frames (PB-frame pairs), each PB-frame pair having a corresponding P-block:

dividing each I-frame or PB-frame pair into a plurality of spatially non-overlapping blocks of pixel data:

encoding the blocks from the I-frame (I-blocks) independently from any other frames in the group of pictures;

predictively encoding the blocks from the second frame of the PB-frame pair (P-blocks), based on the I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair:

bi-directionally predictively encoding the blocks from the first frame of the PB-frame pair (B-blocks), based on the I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair and the corresponding P-block in the current PB-frame pair:

deriving a scaled forward motion vector and a scaled backward motion vector for the B-block by scaling the motion vector of the corresponding P-block in the current PB-frame pair:

obtaining a final forward motion vector for the B-block by adding a delta motion vector to the scaled forward motion vector: and

obtaining a final backward motion vector for the B-block by subtracting the delta motion vector from the scaled backward motion vector.

2. A method for encoding a sequence of video image frames according to claim 1, wherein

the scaling of the motion vector is based on a temporal reference of the first and second frames of the PB-frame pair.

3. A method for encoding a sequence of video image frames according to claim 1, further comprising the step of forming an encoded output, wherein the encoded output is a bitstream comprising:

temporal reference information for the first and second frames of the PB-frame pairs:

motion vector information for the P-blocks:

quantized residual error information for the P-blocks:

delta motion vector information for the B-blocks; and

quantized residual error information for the B-blocks.

4. A method for encoding a sequence of video image frames according to claim 3, wherein

the output bitstream contains additional information to indicate the presence of at least one of:

the delta motion vector information for the B-blocks; and

the quantized residual error information for the B-blocks.

5. A method for decoding a sequence of video image frames comprising the steps of:

decoding the compressed video image sequence as a set of group of pictures, each group of pictures comprising an I-frame followed by a plurality of PB-frame pairs, each PB-frame pair having a corresponding P-block:

decoding each I-frame or PB-frame pair into a plurality of spatially non-overlapping blocks of pixel data:

decoding the I-blocks from the I-frame independently from any other frames in the group of pictures:

predictively decoding the P-blocks from the second frame of the PB-frame pair based on the I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair:

bi-directionally predictively decoding the B-blocks from the first frame of the PB-frame pair based on the

I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair and the corresponding P-block in the current PB-frame pair;

deriving a scaled forward motion vector and a scaled backward motion vector for the B-block by scaling the motion vector of the corresponding P-block in the current PB-frame pair;

obtaining a final forward motion vector for the B-block by adding a delta motion vector to the scaled forward motion vector; and

obtaining a final backward motion vector for the B-block by subtracting the delta motion vector from the scaled backward motion vector.

6. A method for decoding a sequence of video image frames according to claim 5, further comprising the step of forming a decoded output, wherein the decoded output is responsive to a bitstream comprising:

temporal reference information for the first and second frames of the PB-frame pairs;

motion vector information for the P-blocks;

quantized residual error information for the P-blocks;

the delta motion vector information for the B-blocks; and

quantized residual error information for the B-blocks.

7. A method for decoding a sequence of video image frames according to claim 6, wherein

the bitstream contains additional information to indicate the presence of at least one of:

the delta motion vector information for the B-blocks; and

the quantized residual error information for the B-blocks.

8. A method of decoding a sequence of video image frames according to claim 5, wherein

the scaling is based on a temporal reference of the first and second frames of the PB-frame pair.

9. An apparatus for encoding a sequence of video image frames comprising:

means for encoding each frame in a sequence of video image frames into a set of group of pictures, each group of pictures comprising an I-frame followed by a plurality of PB-frame pairs;

means for dividing the I-frame and the PB-frame pair into a plurality of spatially non-overlapping blocks of pixel data;

means for encoding and decoding the I-blocks of the I-frame independently from any other frames in the group of pictures;

means for storing the decoded I-blocks to predictively encode subsequent frames;

means for predictively encoding and decoding the P-blocks of the second frame of the PB-frame pair based on the I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair;

means for storing the decoded P-blocks to predictively encode subsequent frames;

means for deriving a scaled forward motion vector and a scaled backward motion vector for a B-block by scaling the motion vector of the corresponding P-block in the current PB-frame pair, the B-block being the first frame of the PB-frame pair;

means for obtaining a final forward motion vector for the B-block by adding a delta motion vector to the scaled forward motion vector;

means for obtaining a final backward motion vector for the B-block by subtracting the same delta motion vector from the scaled backward motion vector; and

means for encoding the B-blocks of the first frame of the PB-frame pairs based on the I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair and the corresponding P-block in the current PB-frame pair using the final forward motion vector and the final backward motion vector.

10. An apparatus for decoding a sequence of video image frames comprising:

means for decoding each frame in a sequence of video image frames into a set of group of pictures, each group of pictures comprising an I-frame followed by a plurality of PB-frame pairs;

means for decoding the I-blocks of the I-frame independently of any other frames in the group of pictures;

means for storing the decoded I-blocks to predictively decode subsequent frames;

means for decoding the P-blocks of the second frame of the PB-frame pair based on the I-blocks in the previous I-frame or the P-blocks in the previous PB-frame pair;

means for storing the decoded P-blocks to predictively decode subsequent frames;

means for deriving a scaled forward motion vector and a scaled backward motion vector for a B-block by scaling the motion vector of the corresponding P-block in the current PB-frame pair, the B-block being the first frame of the PB-frame pair;

means for obtaining a final forward motion vector for the B-block by adding a delta motion vector to the scaled forward motion vector;

means for obtaining a final backward motion vector for the B-block by subtracting the delta motion vector to the scaled backward motion vector; and

means for decoding the B-blocks of the first frame of the PB-frame pairs based on the I-blocks in the previous I-frame of the P-blocks in the previous PB-frame pair and the corresponding P-block in the current PB-frame pair using the final forward motion vector and the final backward motion vector.

11. A method for encoding a sequence of video image frames comprising the steps of:

dividing a source sequence into a plurality of groups of pictures, each group of pictures comprising a first frame (I-frame) followed by a plurality of pairs of predictively encoded frames (PB-frame pairs);

dividing each I-frame or PB-frame pair into a plurality of blocks;

encoding the blocks from the I-frame;

predictively encoding the blocks from the second frame of the PB-frame pair;

bi-directionally predictively encoding the blocks from the first frame of a PB-frame pair (B-blocks);

deriving a scaled forward motion vector and a scaled backward motion vector for the B-block;

obtaining a final forward motion vector for the B-block by adding a delta motion vector to the scaled forward motion vector; and

obtaining a final backward motion vector for the B-block by subtracting the delta motion vector from the scaled backward motion vector.

12. An apparatus for encoding a sequence of video image frames comprising:

means for dividing a source sequence into a plurality of groups of pictures, each group of pictures comprising a

first frame (I-frame) followed by a plurality of pairs of predictively encoded frames (PB-frame pairs);

means for dividing each I-frame or PB-frame pair into a plurality of blocks:

means for encoding the blocks from the I-frame:

means for predictively encoding the blocks from the second frame of the PB-frame pair;

means for bi-directionally predictively encoding the blocks from the first frame of a PB-frame pair (B-blocks);

means for deriving a scaled forward motion vector and a scaled backward motion vector for the B-block;

means for obtaining a final forward motion vector for the B-block by adding a delta motion vector to the scaled forward motion vector; and

means for obtaining a final backward motion vector for the B-block by subtracting the delta motion vector from the scaled backward motion vector.

* * * * *

13. A method for encoding a sequence of video image frames comprising the steps of:

dividing a source sequence into a group of pictures, each group of pictures comprising an I-frame followed by a plurality of P-frames and B-frames,

dividing each I-frame, P-frame and B-frame into a plurality of spatially non-overlapping blocks of pixel data;

encoding a block in the I-frame independently from any other frames in the group of pictures;

predictively encoding a block in a P-frame, based on the I-frame positioned before the P-frame or a previous P-frame positioned before the P-frame;

bi-directionally predictively encoding a block in a B-frame, based on the I-frame positioned before the B-frame or the previous P-frame and the P-frame positioned after the B-frame;

deriving a scaled forward motion vector and a scaled backward motion vector for the block in the B-frame by scaling a motion vector of the block

predictively encoded in the P-frame positioned after the B-frame;

obtaining a final forward motion vector for the block in the B-frame by adding a delta motion vector to the scaled forward motion vector; and

obtaining a final backward motion vector for the block in the B-frame by adding the delta motion vector to the scaled backward motion vector.

14. A method for encoding a sequence of video image frames according to claim 13, wherein the deriving step includes

scaling of the forward and backward motion vectors is based on a temporal reference of the P-frame and B-frame.

15. A method for encoding a sequence of video image frames according to claim 13, further comprising the step of forming an encoded output, wherein the encoded output is a bitstream comprising:

temporal reference information for the B-frame and the P-frame;

motion vector information for the block in the P-frame;

quantized residual error information for the block in the P-frame;

delta motion vector information for the block in the B-frame; and

quantized residual error information for the block in the B-frame.

16. A method for encoding a sequence of video image frames according to claim 15, wherein

the output bitstream contains additional information indicating a presence of at least one of the delta motion vector information for the block in the B-frame; and the quantized residual error information for the block in the B-frame.

US005825421A

United States Patent [19]

Tan

[11] Patent Number: 5,825,421

[45] Date of Patent: Oct. 20, 1998

[54] **VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF**

[75] Inventor: **Thiow Keng Tan**, Singapore, Singapore

[73] Assignee: **Matsushita Electronic Industrial Co., Ltd.**, Osaka, Japan

[21] Appl. No.: **773,574**

[22] Filed: **Dec. 27, 1996**

[30] **Foreign Application Priority Data**

Dec. 27, 1995 [JP] Japan 7-340609

[51] **Int. Cl.**[6] **H04N 7/32**

[52] **U.S. Cl.** **348/409**; 348/413; 348/415; 348/699

[58] **Field of Search** 348/409, 413, 348/415, 396, 416, 699, 402; 382/56; H04N 7/32

[56] **References Cited**

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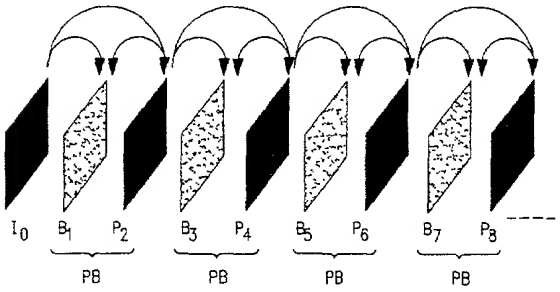
Primary Examiner—Tommy P. Chin
Assistant Examiner—Tung Vo
Attorney, Agent, or Firm—Ratner & Prestia

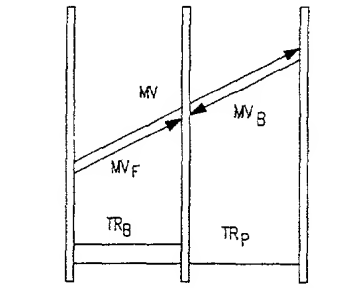
[57] **ABSTRACT**

A new predictive coding is used to increase the temporal frame rate and coding efficiency without introducing excessive delay. Currently the motion vector for the blocks in the bi-directionally predicted frame is derived from the motion vector of the corresponding block in the forward predicted frame using a linear motion model. This however is not effective when the motion in the image sequence is not linear. The efficiency of this method can be further improved if a non-linear motion model is used. In this model a delta motion vector is added to or subtracted from the derived forward and backward motion vector, respectively. The encoder performs an additional search to determine if there is a need for the delta motion vector. The presence of this delta motion vector in the transmitted bitstream is signalled to the decoder which then takes the appropriate action to make use of the delta motion vector to derive the effective forward and backward motion vectors for the bi-directionally predicted block.

12 Claims, 6 Drawing Sheets



PB FRAME PREDICTION



LINEAR MOTION MODEL

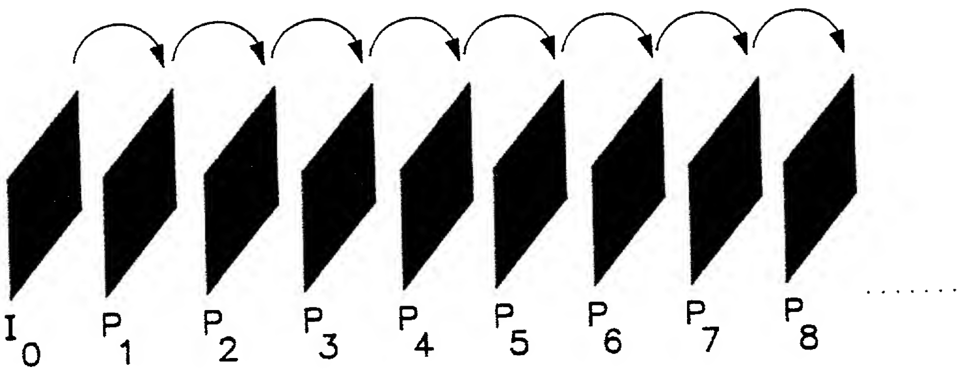


FIG. 1A

PRIOR ART (H.261)

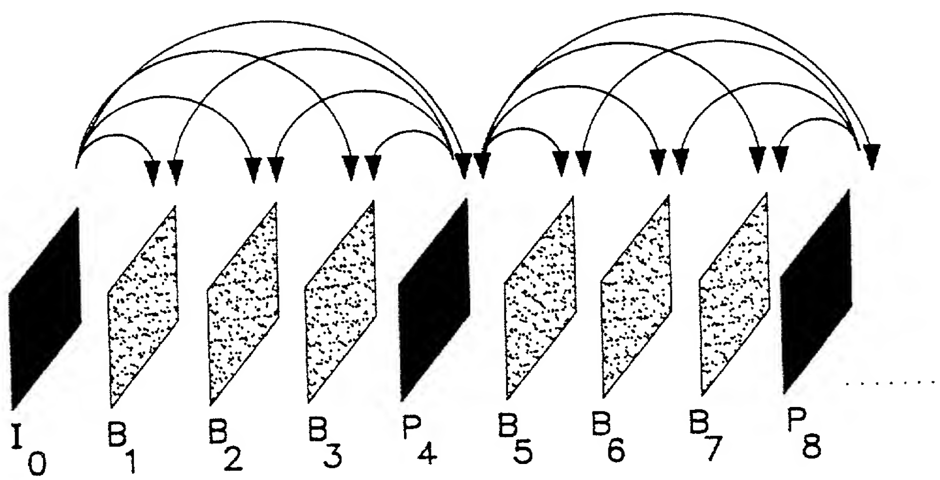
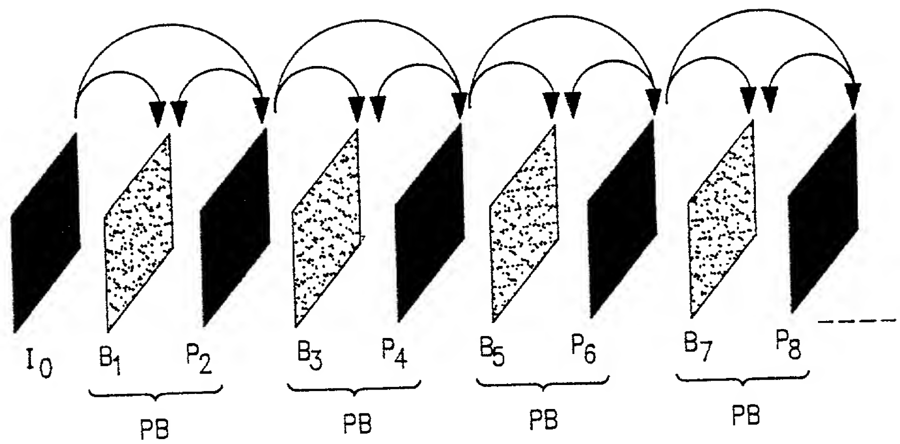


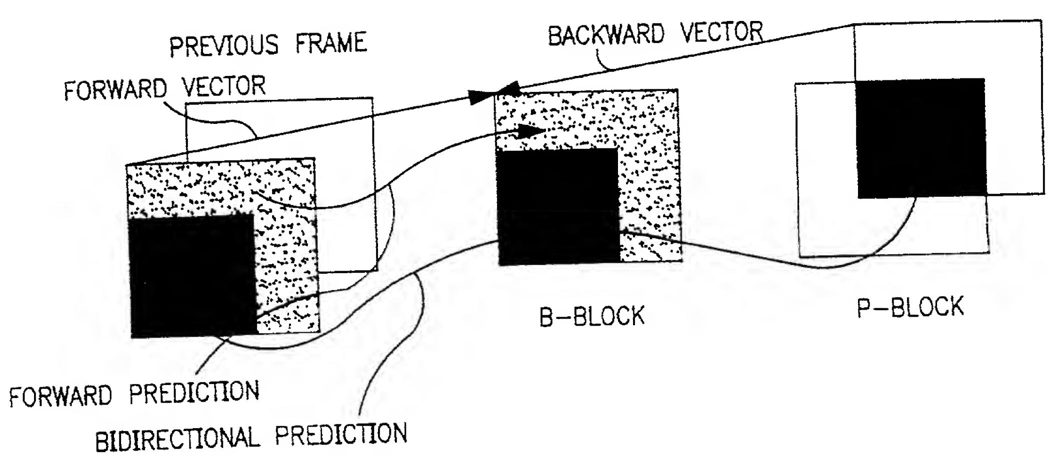
FIG. 1B

PRIOR ART (MPEG)



PB FRAME PREDICTION

FIG. 2A



B-BLOCK PREDICTION

FIG. 2B

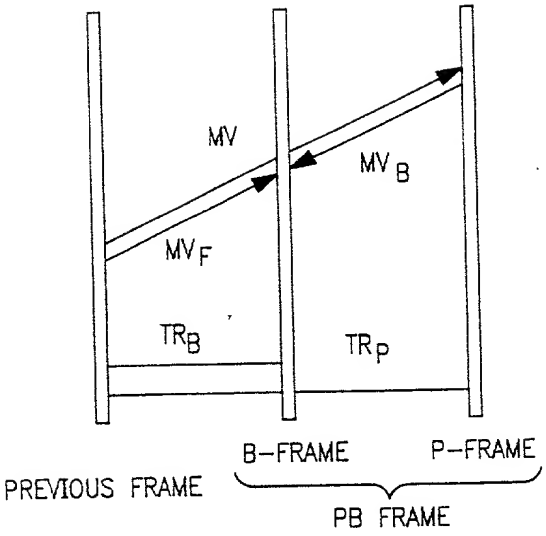

MV
MV B
MV F
TR B
TR P
B–FRAME
P–FRAME
PREVIOUS FRAME
PB FRAME
LINEAR MOTION MODEL

FIG. 3A

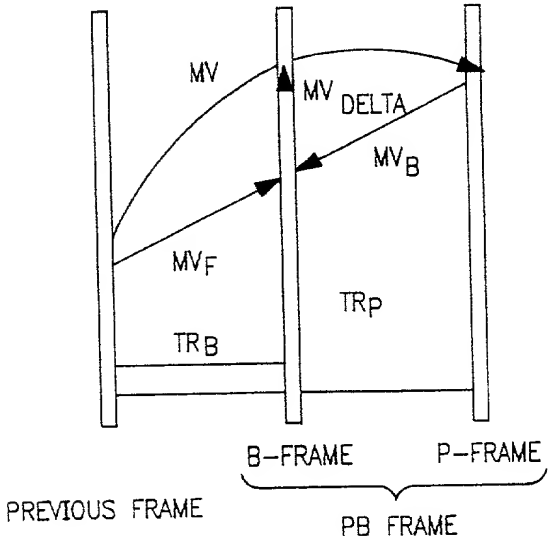

MV
MV DELTA
MV B
MV F
TR P
TR B
B–FRAME
P–FRAME
PREVIOUS FRAME
PB FRAME
NON–LINEAR MOTION MODEL

FIG. 3B

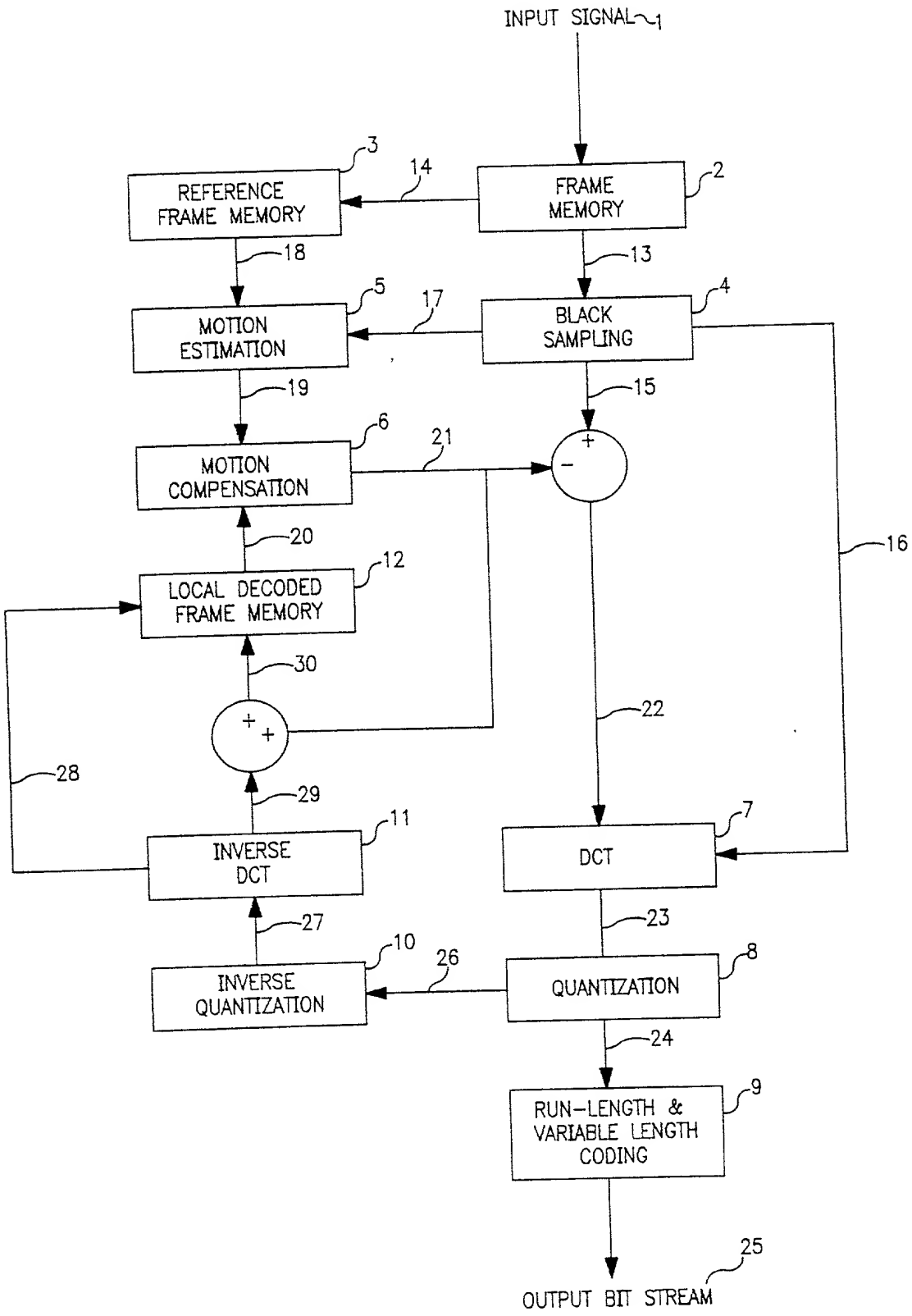

INPUT SIGNAL
1
FRAME MEMORY
2
REFERENCE FRAME MEMORY
3
BLACK SAMPLING
4
MOTION ESTIMATION
5
MOTION COMPENSATION
6
DCT
7
QUANTIZATION
8
RUN-LENGTH & VARIABLE LENGTH CODING
9
INVERSE QUANTIZATION
10
INVERSE DCT
11
LOCAL DECODED FRAME MEMORY
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
OUTPUT BIT STREAM

FIG. 4

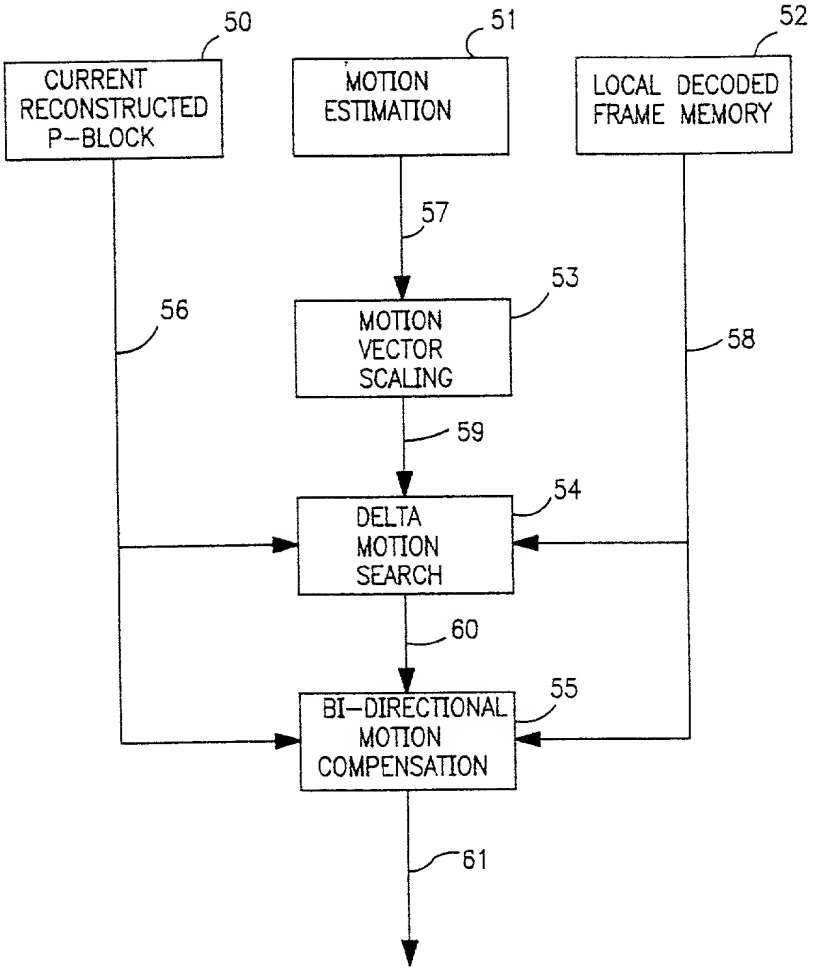


FIG. 5

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REISSUE APPLICATION DECLARATION BY THE ASSIGNEE

Docket Number (optional): MTS-880US1

I hereby declare that:

My residence and post office address and citizenship are stated below next to my name.

I am authorized to act on behalf of the following assignee: Matsushita Electric Industrial Co., Ltd.

and the title of my position with said assignee is: Director

The entire title to the patent identified below is vested in said assignee.

Name of Patentee(s): Thiow Keng Tan

Patent Number	Date of Patent Issued
5,825,421	October 20, 1998

Title of Invention: VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

I believe said patentee(s) to be the original, first and sole/joint inventor(s) of the subject matter which is described and claimed in said patent, for which a reissue patent is sought on the invention entitled VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF,

the specification of which

[X] is attached hereto.

[ ] was filed on _____ as reissue application number _____
and was amended on _____
(If applicable)

I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I verily believe the original patent to be wholly or partly inoperative or invalid, for the reasons described below. (Check all boxes that apply.)

[ ] by reason of a defective specification or drawing.

[X] by reason of the patentee claiming more or less than he had the right to claim in the patent.

[ ] by reason of other errors.

At least one error upon which reissue is based is described as follows:

During the prosecution of the application that issued as the above patent, the inventors did not recognize that the features disclosed in new claims 13-16 were appropriate to claim. As such, the inventors did not claim all that they had a right to claim. This error was made without deceptive intent.

[Attach additional sheets, if needed.]

All errors corrected in this reissue application arose without any deceptive intention on the part of the applicant.

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(REISSUE APPLICATION DECLARATION BY THE ASSIGNEE, page 2)

Docket Number (Optional) MTS-880US1

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Name(s)	Registration Number
Allan Ratner	19,717
Jack J. Jankovitz	42,690

Correspondence Address: Direct all communications about the application to:

☐ Customer Number [ ] → *Place Customer Number Bar Code Label Here*

Type Customer Number Here

OR

☒ Firm or Individual Name	Allan Ratner; Ratner & Prestia				
Address	P.O. Box 980				
Address					
City	Valley Forge	State	PA	Zip	19482
Country					
Telephone	(610) 407-0700	Fax	(610) 407-0701		

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine and imprisonment, or both, under 18 U.S.C. 1 001, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this declaration is directed.

Full name of person signing (given name, family name)
Dr. Osamu Yamazak, Director

Signature	Date

Address of Assignee 1006, Oaza Kadoma, Kadoma-shi Osaka, 571 Japan

Patentee	Citizenship
Thiow Keng Tan	Malaysia

Residence/Post Office Address Block 553, Choa Chu Kang North 6, 11-08 Singapore 2368

Patentee	Citizenship

Residence/Post Office Address

Please type a plus sign (+) inside this box → [+]

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DECLARATION

REGISTERED PRACTITIONER INFORMATION (Supplemental Sheet)

Name	Registration Number	Name	Registration Number
Kevin R. Casey	32,117		
Benjamin E. Leace	33,412		
James C. Simmons	24,842		
Lawrence E. Ashery	34,515		
Christopher R. Lewis	36,201		
Robert L. Andersen	25,771		
Daniel N. Calder	27,424		
Louis W. Beardell, Jr.	40,506		
Jacques L. Etkowicz	41,738		
Jonathan H. Spadt	45,122		
Mark J. Marcelli	38,040		
Joshua L. Cohen	42,690		
Jack J. Jankovitz	34,608		
Kevin W. Goldstein	42,621		
Christopher I. Halliday	26,277		
Paul D. Golian	33,602		
William P. Hauser	41,712		
Bruce M. Monroe	28,028		
Rex A. Donnelly, IV	42,866		
Costas Krikelis			

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REISSUE APPLICATION DECLARATION BY THE INVENTOR	Docket Number (Optional) MTS-880US1

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is described and claimed in patent number 5,825,421, granted October 20, 1998, and for which a reissue patent is sought on the invention entitled VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF,
the specification of which

[X] is attached hereto.

[ ] was filed on _____ as reissue application number ___ / _____
and was amended on _____ .
(If applicable)

I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I verily believe the original patent to be wholly or partly inoperative or invalid, for the reasons described below. (Check all boxes that apply.)

[ ] by reason of a defective specification or drawing.

[X] by reason of the patentee claiming more or less than he had the right to claim in the patent.

[ ] by reason of other errors.

At least one error upon which reissue is based is described as follows:

During the prosecution of the application that issued as the above patent, the inventors did not recognize that the features disclosed in new claims 13-16 were appropriate to claim. As such, the inventors did not claim all that they had a right to claim. This error was made without deceptive intent.

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(REISSUE APPLICATION DECLARATION BY THE INVENTOR, page 2)

Docket Number (Optional): MTS-880US1

All errors corrected in this reissue application arose without any deceptive intention on the part of the applicant. As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Name(s)	Registration Number
Allan Ratner	19,717
Jack J. Jankovitz	42,690

Correspondence Address: Direct all communications about the application to:

☐ Customer Number [ ] [ ]

OR

Type Customer Number here

Place Customer Number Bar Code Label here

☒ Firm or Individual Name	Ratner & Prestia				
Address	P.O. Box 980				
Address					
City	Valley Forge	State	PA	ZIP	19482
Country					
Telephone	(610) 407-0700	Fax	(610) 407-0701		

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine and imprisonment, or both, under 18 U.S.C. 1001, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this declaration is directed.

Full name of sole or first inventor (given name, family name): Thiow Keng Tan

Inventor's signature

Residence: Singapore — Date

Post Office Address: Block 553, Choa Chu Kang North 6, #11-08 Singapore 2368 — Citizenship: Malaysia

Full name of second joint inventor (given name, family name)

Inventor's signature — Date

Residence — Citizenship

Post Office Address

Full name of third joint inventor (given name, family name)

Inventor's signature — Date

Residence — Citizenship

Post Office Address

☐ Additional joint inventors are named on separately numbered sheets attached hereto.

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Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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DECLARATION

REGISTERED PRACTITIONER INFORMATION (Supplemental Sheet)

Name	Registration Number	Name	Registration Number
Paul F. Prestia	23,031		
Andrew L. Ney	20,300		
Kevin R. Casey	32,117		
Benjamin E. Leace	33,412		
James C. Simmons	24,842		
Lawrence E. Ashery	34,515		
Christopher R. Lewis	36,201		
Robert L. Andersen	25,771		
Daniel N. Calder	27,424		
Louis W. Beardell, Jr.	40,506		
Jacques L. Etkowicz	41,738		
Jonathan H. Spadt	45,122		
Mark J. Marcelli	38,040		
Joshua L. Cohen	42,690		
Jack J. Jankovitz	34,608		
Kevin W. Goldstein	42,621		
Christopher I. Halliday	26,277		
Paul D. Golian	33,602		
William P. Hauser	41,712		
Bruce M. Monroe	28,028		
Rex A. Donnelly, IV	42,866		
Costas Krikelis			

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Practitioner's Docket No. MTS-880US1 *PATENT*

REQUEST FOR TRANSFER OF DRAWINGS FROM ORIGINAL PATENT TO REISSUE APPLICATION

Please transfer the drawings from original patent, 5,825,421, issued on October 20, 1998, for the invention entitled VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF to the reissue application, the specification of which is attached hereto.

Date: 10/18/00

Allan Ratner, Reg. No. 19,717
Jack J. Jankovitz, Reg. No. 42,690
Ratner & Prestia
P.O. Box 980
Valley Forge, PA 19482

PTO/SB/53 (12-97)
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REISSUE APPLICATION BY THE INVENTOR, OFFER TO SURRENDER PATENT

Docket Number (Optional)
MTS-880US1

This is part of the application for a reissue patent based on the original patent identified below.

Name of Patentee(s)
Thiow Keng Tan

Patent Number	Date Patent Issued
5,825,421	October 20, 1998

Title of invention
VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

I am the inventor of the original patent.

I offer to surrender the original patent.

1. [X] Filed herein is a certificate under 37 CFR 3.73(b).

2. [ ] Ownership of the patent is in the inventor(s), and no assignment of the patent has been made.

One of boxes 1 or 2 above must be checked.

The written consent of all assignees owning an undivided interest in the original patent is included in this application for reissue.

Signature	Date

Typed or printed name
Thiow Keng Tan

The assignee owning an undivided interest in said original patent is Matsushita Electric Industrial Co , Ltd. , and the assignee consents to the accompanying application for reissue.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application, any patent issued thereon, or any patent to which this declaration is directed.

Name of assignee
Matsushita Electric Industrial Co., Ltd

Signature of person signing for assignee	Date

Typed or printed name and title of person signing for assignee
Dr. Osamu Yamazaki Director

PTO/SB/54 (12-97)
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REISSUE APPLICATION BY THE ASSIGNEE, OFFER TO SURRENDER PATENT	Docket Number (Optional) MTS-880US1

This is part of the application for a reissue patent based on the original patent identified below.

Name of Patentee(s):
Thiow Keng Tan

Patent Number	Date Patent Issued
5,825,421	October 20, 1998

Title of Invention: VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

Matsushita Electric Industrial Co., Ltd. is the assignee of the entire interest in the original patent.

I offer to surrender the original patent.

[X] A certificate under 37 CFR 3.73(b) is attached.

I am authorized to act on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application, any patent issued thereon, or any patent to which this declaration is directed.

Name of assignee
Matsushita Electric Industrial Co., Ltd.

Signature of person signing for assignee	Date

Typed or printed name and title of person signing for assignee

Dr. Osamu Yamazaki Director

Practitioner's Docket No. MTS-880US1 *PATENT*

ASSENT BY ASSIGNEE FOR FILING OF REISSUE APPLICATION

This is part of the application for a reissue patent filed herewith based on the original patent identified as follows:

Name of Patentee: Matsushita Electric Industrial Co , Ltd.
Patent Number: 5,825,421
Date Patent Issued: October 20, 1998
Title of Invention: VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

I am an assignee owning an undivided interest to the above original patent.

I assent to the accompanying application for reissue

Attached is a "Certificate under 37 C.F.R. section 3.73(b)"

Matsushita Electric Industrial Co., Ltd.

_____ Date: _____

Signature of person signing for assignee

Dr. Osamu Yamazaki
Director

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: T. Tan : Art Unit:
Serial No.: To Be Assigned : Examiner:
Filed: Herewith
FOR: VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

CERTIFICATE UNDER 37 CFR 3.73 (b)

Assistant Commissioner for Patents
Washington, D.C. 20231

S I R :

Matsushita Electric Industrial Co., Ltd., a Japanese Corporation certifies that it is the assignee of the entire right, title and interest in the patent application identified above by virtue of an assignment from the inventor of the patent application identified above. The assignment was recorded in the Patent and Trademark Office at Reel 8607, Frame 0024, for which a copy thereof is attached.

The undersigned has reviewed all the documents in the chain of title of the patent application identified above and, to the best of undersigned's knowledge and belief, title is in the assignee identified above.

The undersigned (whose title is supplied below) is empowered to act on behalf of the assignee.

I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by

fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date : ______________________

Name :Dr. Osamu Yamazaki

Title :Director

Signature : ______________________

mts-880

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AUGUST 14, 1997

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RECORDATION DATE: 07/15/1997

REEL/FRAME: 8607/0024
NUMBER OF PAGES: 3

BRIEF: ASSIGNMENT OF ASSIGNOR'S INTEREST (SEE DOCUMENT FOR DETAILS).

ASSIGNOR:
TAN, THIOW KENG

DOC DATE: 03/03/1997

ASSIGNEE:
MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
1006, OAZA KADOMA, KADOMA-SHI
OSAKA, JAPAN 571

SERIAL NUMBER: 08773574
PATENT NUMBER:

FILING DATE: 12/27/1996
ISSUE DATE:

MAYA BENNETT, EXAMINER
ASSIGNMENT DIVISION
OFFICE OF PUBLIC RECORDS

No legalization required

ASSIGNMENT

WHEREAS, the ASSIGNOR, comprising the following named inventor(s)

Inventor(s)

ASSIGNOR(s)/ INVENTOR(s)

1. Tan, Thiow Keng 2. _____

3. _____ 4. _____

has made an invention entitled: _____

VIDEO CODING METHOD AND DECODING METHOD AND DEVICES THEREOF

and has executed an application for Letters Patent of the United States concurrently herewith;

WHEREAS, the ASSIGNEE

ASSIGNEE (Full Name and address)

Matsushita Electric Industrial Co., Ltd.

of 1006, Oaza Kadoma, Kadoma-shi, Osaka 571 JAPAN

is desirous of acquiring the entire interest in and to said invention and the Letters Patent to be obtained therefor,

NOW, THEREFORE, in consideration of the payment by ASSIGNEE to ASSIGNOR of a sum corresponding to One Dollar ($1.00), and for other good and valuable consideration, the receipt of which is hereby acknowledged, ASSIGNOR, intending to be legally bound, hereby sells, assigns and transfers to ASSIGNEE, its successors and assigns the full and exclusive right, title and interest in and to said invention, all applications for Letters Patent for said invention, including all divisions and continuations thereof, all rights to claim priority based thereon, and all Letters Patent, including reissues, to be obtained therefor, including any and all foreign patent rights in this invention corresponding thereto.

ASSIGNOR hereby warrants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this Assignment.

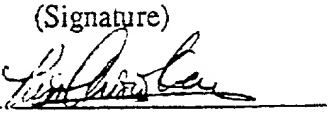
ASSIGNOR agrees it shall be legally bound, upon request of the ASSIGNEE or its successors or assigns or a legal representative thereof, to supply all information and evidence of which the ASSIGNOR has knowledge or possession, relating to the making and practice of said invention, to testify in any legal proceeding relating thereto, to execute all instruments proper to patent the invention in the United States of America and foreign countries in the name of the ASSIGNEE, and to execute all instruments proper to carry out the intent of this instrument.

If the invention requires a biological deposit, ASSIGNOR also grants to ASSIGNEE such control over any deposit made by ASSIGNOR as may be necessary to the validity of the patent rights assigned herein.

ASSIGNOR authorizes ASSIGNOR's attorney to insert at the end hereof the serial number and filing date of the aforesaid application for United States Letters Patent and/or the Attorney docket or file designation for this application.

If the ASSIGNOR includes more than one individual, these obligations shall apply to these individuals both individually and collectively.

IN WITNESS WHEREOF, this Assignment is executed on the day indicated below.

	(Typed or Printed Name)	(Signature)	(Date)
SIGNATURE	1. Tan, Thiow Keng		March 3, 1997
	2. _____	_____	_____
	3. _____	_____	_____
	4. _____	_____	_____

Application for United States Letters Patent

Serial No. 08/773,574 Filed December 27, 1996

Attorney Docket No. MTS-650.